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MOSSES OF WYOMING'S BEARTOOTH PLATEAU: NEW NOTEWORTHY RECORDS FOR THE ROCKY MOUNTAIN REGION

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ABSTRACT

Six moss species are reported for the first time from Wyoming: *Hygrohypnum styriacum, Imbribryum muehlenbeckii, Philonotis yezoana, Plagiobryum zierii, Sanionia georgico-uncinata,* and *Thuidium recognitum.* The genera *Plagiobryum* and *Thuidium* are new to the state flora. Newly found taxa were documented at elevations of 2000–3260 meters in the Beartooth Plateau region. All of them are considered rarities in this portion of the Rocky Mountains. Remarkable is the discovery in the interior mountains of Wyoming of *Philonotis yezoana*, the globally rare East Asian and North American species of primarily oceanic temperate habitats — collections documented here were made 1100 kilometers from the nearest coast.

KEY WORDS: mosses, Wyoming, Beartooth Plateau, Rocky Mountains

This note is part of the first author's ongoing research on the bryoflora of Wyoming's Beartooth Plateau, located in the central Rocky Mountains of northwestern Wyoming (Fig. 1). Most of the Beartooth Plateau is located in Montana — the research is within the small southeastern corner of the Plateau, which stretches from Montana into Wyoming. This study is being conducted within the framework of bryophyte inventory projects on the Shoshone National Forest (SNF), begun in 2008. A physiogeographical description of the study area is given in previous articles (Kosovich-Anderson & Ignatov 2010; Kosovich-Anderson 2011). Six species are reported here that were not listed in Eckel's county checklist of Wyoming mosses (2007). All cited voucher specimens are housed in RM with duplicates in the author's personal herbarium; if they are elsewhere the herbaria are noted.

1. *HYGROHYPNUM STYRIACUM* (Limpricht) Brotherus (Amblystegiaceae). An arctic-alpine or montane species, typically occurring at alpine and subalpine elevations on wet rocks near flowing water, inundated or splashed, and in irrigated crevices of granite or slate rocks. It is known in Europe from the Alps and Tatras (Carpathian Mountains) and mountainous regions of Scandinavia, Britain, and Scotland (Nyholm 1965; Frey et al. 2006). A recent record from Spain marks the southern limit of its range in Europe (Rams & Olivan 2006). Outside of Europe it has been reported from Greenland and western North America; in the Rocky Mountains it occurs from British Columbia and Alberta to Montana, Idaho, and Utah, with the easternmost known station in Clear Creek County, Colorado, *Weber B-111133*, and extending westward to California (Goldberg 2003; Norris & Shevock 2004; Weber & Wittmann 2007; Jamieson 2011). *Hygrohypnum styriacum* is rare across most of its range. It is classified as "Imperiled" in British Columbia and "Critically Endangered" in Britain.

Figure 1. Wyoming's Beartooth Plateau, Rocky Mountains. Photo by R. Anderson.

Collection Data. Wyoming, Park Co., SNF, Beartooth Plateau: Beartooth Creek, granite debris along the creek; attached to boulders periodically wet by spray and seasonally covered with fast flowing water, assoc. with *Scouleria aquatica*, T57N R105W S7, 44° 56.270-280' N, 109° 36.010-020' W, elev. ca. 8,900 ft (2700 m), 23 Aug 2009, *Kosovich-Anderson 5431* (COLO); Beartooth Lake, W and SW shore, *Picea engelmannii* forest along the shore, on wet clay, assoc.: *Sanionia uncinata, Calliergonella cuspidata*, T57N R105W S6&7, 44° 56.500-520' N, 109°35.980-990' W, elev. ca. 8,900 ft (2700 m), 24 Jul 2010, *Kosovich-Anderson 6652*.

Both cited specimens have abruptly acuminate and reflexed leaf apices, typical for the species. In the newly prepared volume of Flora of North America (Jamieson 2011), the Wyoming occurrence of *Hygrohypnum styriacum* is based on *Kosovich-Anderson 5431*.

2. *IMBRIBRYUM MUEHLENBECKII* (Bruch & Schimper) Pedersen [*Bryum muehlenbeckii* Bruch & Schimper] **(Bryaceae).** A montane species, widely distributed but uncommon and generally rare in most parts of its range: Eurasia, Greenland, North America, and Atlantic Islands (Madeira). Southern Hemisphere collections are referred to other species. It occurs on acidic, very rarely calcareous, damp shaded rocks, soil in rock crevices, especially near streams and waterfalls, occasionally at mineral-rich springs, sometimes submerged in shallow water; elev. 500-3000 m (Frey et al. 2006; Spence 2010). The species is infrequent and scattered across North America from Newfoundland and Labrador to New England and Ontario, south to Michigan, New York, Pennsylvania, and Tennessee; from British Columbia to California and inland to Nevada, Utah, New Mexico, Idaho and Montana (Crum & Anderson 1981; Spence 2010).

Collection Data. Wyoming, Park Co., SNF, Beartooth Plateau: SE shore of Island Lake, ecotone zone between willow wetlands and subalpine *Picea engelmannii* forest, on wet loamy soil, in shade, T57N R105W S3, 44°56.690-700' N, 109°32.230-240' W, elev. ca. 9,500 ft (2900 m), 12 Aug 2008, *Kosovich-Anderson 2371* (ASC, COLO, DUKE) (det. by J. Spence).

The Park County collection is represented by small (up to 0.5 cm high) plants, dark green-red in color, with somewhat julaceous stems. According to Spence (2010), forms like these are morphologically close to small forms of the boreal-temperate *Imbribryum alpinum* (Hudson ex Withering) Pedersen but have strongly concave, ovate leaves, short distal laminal cells, and a weak costa. Both species are extremely variable, rarely form capsules, and difficult to identify.

Imbribryum muehlenbeckii is the second species of the genus documented for Wyoming after the recently reported *I. gemmiparum* (De Notaris) J.R. Spence [= *Bryum gemmiparum* De Notaris] (Spence 2010).

***3. PHILONOTIS YEZOANA* Bescherelle & Cardot in J. Cardot (Bartramiaceae).** Fig. 2. Globally rare species (conservation rank G2G3). *Philonotis yezoana* is an East Asian and North American species, originally described from Japanese and Korean specimens (Zales 1973). The species has a scattered distribution across the North American continent, mainly confined to the states and provinces of the Pacific and north Atlantic coast. The first record for Greenland was recently reported by Koponen (2009).

In the USA, *Philonotis yezoana* has isolated stations on the New England coast (Vermont, New York, and New Hampshire), scattered populations are also found along the Pacific coast (southeastern Alaska, Washington, and California), and several inland occurrences are known in northwestern Montana and central Idaho (Zales 1973; Crum & Anderson 1981; Griffin 2003; Kekes 2006; Duke Bryophyte Collection). Reportedly, *P. yezoana* is a species of primarily oceanic temperate habitats, but the species successfully survives under the conditions of hot and dry summer of interior California, where it occurs in mixed conifer forests of Sierra Nevada at the elevation 2000 m growing on seasonally dry rocks, receiving primarily winter snow as precipitation (Shevock, pers. comm.). In the mountains of Wyoming's Beartooth Plateau, *P. yezoana* was found growing in typical for the species situation – on wet granite rocks in the splash zone of the rapids of montane creek.

The Wyoming occurrence is unusual in being so far inland: it was registered 1100 km away from the nearest coast, in the interior mountains of the state, far east of the known disjunct sites in northwestern Montana and central Idaho. The eastern extension of plant species with Pacific coastal affinities is well known. The phenomenon, attributable to westerly winds that carry an oceanic climate influence well inland to the northern Rocky Mountains, has been observed in both vascular plants and bryophytes (Schofield 1965; Ahti & Fagersten 1967). It is reasonable to assume that these disjunct colonies of *P. yezoana* are the result of elimination of connecting habitats rather than relatively recent migrations.

Collection Data. Wyoming, Park Co., SNF, Beartooth Plateau: Lake Creek: rapids, overlook "Lake Creek Waterfall" 50 m N of HWY 212, sheltered granite outcrops lining the waterfall, under the steep bank forested by *Pseudotsuga menziesii, Pinus contorta*, and *Picea* sp. on thin wet soil covering an outcrop's surface, shaded by spruce, in splash zone of the waterfall, assoc.: *Blindia acuta* and leafy liverworts, T57N R107W S8, 44°55.485-490' N, 109°41.670-675' W, elev. ca. 7,500 ft (2280 m), 26 Aug 2009, *Kosovich-Anderson 5850* (COLO, DUKE); steep rocky bank forested with *Picea* sp., over rock on a patch of soil, in splash zone of creek, forms scarce admixture to *Scapania* sp., T57N R107W S17, 44°55.350-355' N, 109°42.430-435' W, elev. ca. 6,900 ft (2100 m), 5 Aug 2010, *Kosovich-Anderson 8397.*

Figure 2. *Philonotis yezoana*, habit. Photo by Y. Kosovich-Anderson.

Both documented populations of *Philonotis yezoana* have signs of low vitality: scant and sterile plants in poor mats, intermingled with other bryophytes. However, the Wyoming plants of *P. yezoana* are distinctive in morphology — the irregularly subquadrate and rectangular leaf cells with single massive central papillae on both surfaces, along with the dark green color, make the species easy to recognize.

4. *PLAGIOBRYUM ZIERII* (Hedwig) Lindberg (Bryaceae). Fig. 3. A species and genus new to Wyoming. *Plagiobryum zierii* is a rare arctic-alpine species with a disjunct circumboreal distribution in Eurasia, Africa, North America, and Central America (Guatemala), typically growing on wet dripping rocks and in crevices of cliffs (most frequently basic), often in the spray zone of waterfalls and also in tundra communities and on soil faces of frost boils and other erosional features of wet tundra. In North America, the species is represented by scattered populations from Greenland to Quebec, Newfoundland, and Labrador, south to Vermont and disjunct to Manitoba; from Alaska, Yukon, and Northwest Territories south through the Rocky Mountains to Oregon and inland to Idaho, Montana and Colorado (Ireland 1982; Hedderson 2007).

Figure 3. *Plagiobryum zierii*, habit. Photo by Y. Kosovich-Anderson.

In Wyoming's neighboring states, *Plagiobryum zierii* is a rarely collected species. A few populations are known in Colorado, where it was found in four counties growing on subalpine seeping cliffs and in moist tundra (Weber & Wittmann 2007). Reports from Montana are based only on the collection of Williams, made at the end of 19th century, at Great Falls in Glacier National Park (Elliott 1993). On the Beartooth Plateau, the species was discovered in two places at a distance of 10 kilometers from each other –– on Clarks Fork of Yellowstone River and Crazy Creek, on rocks in the spray zone.

As Spence believes (pers. comm.), the species is probably relictual in the Rocky Mountains south of the glacial maximum and presumably reached its current distribution during the Pleistocene. Populations south of the glacial ice sheets in the Rockies survived in refugia such as Colorado and expanded north during the Holocene.

Collection Data. Wyoming, Park Co., SNF, foothills of the Beartooth Plateau: Clarks Fork of Yellowstone River, immediately SE of junction of Muddy Creek and Clarks Fork of Yellowstone River, gravel shore of Clarks Fork, massive granite boulders along the shore in seasonal splash zone, on wet clayey substrate in a rock crevice, not abundant, T57N R107W S28, 44°53.965-970'N, 109°40.310-315'W, elev. ca. 6,600 ft (2000 m), 26 Aug 2009, *Kosovich-Anderson 5951* (ASC, COLO) (Det. by J. Spence); approx. 0.05 mi N-NE of Clarks Fork of Yellowstone River and Crazy Creek confluence, cataracts of Crazy Creek, seeping granite cliff, on a soaked humus soil, in shade, scattered among other bryophytes: *Cephaloziella* sp. and *Mnium* sp. T57N R107W S3&10, 44°56.600-620'N, 109°46.555-565'W, elev. ca. 6,900 ft (2100 m), 3 Aug 2010, *Kosovich-Anderson 7972.*

The collections from Wyoming represent plants typical of this taxon, with julaceous, white and silvery green shoots reddish below and broadly ovate, flat-margined leaves. Both specimens are sterile.

The genus *Plagiobryum* Lindberg is new for the Wyoming flora. It is predominantly an alpine genus, easily recognized when fruiting by the large, gibbous and zygomorphic capsules although gametophytically not well-separated from *Bryum* sensu lato. Important generic features are the following (on Shaw 1982, with additions by Spence): stems simple or forking when sterile, innovating abundantly when bearing gametangia; leaves of innovations smaller than those of main stems; costa rather narrow, ending below the apex to excurrent; cells thin-walled, laxly hexagonal or rhomboidal, very long; dioicous; seta rather short and stout, geniculate; capsules horizontal to nodding, zygomorphic; exostome teeth narrowly lanceolate, shorter than the endostome segments, rather abruptly narrowed from an orange base; strongly bordered, trabeculate segments of endostome narrow but keeled, narrowly perforate; spores coarsely papillose to reticulate or warty, often remaining in tetrads at capsule maturity.

5. *SANIONIA GEORGICO-UNCINATA* (Müller Halle) R. Ochyra & L. Hedenäs [*S. nivalis* Hedenäs] **(Amblystegiaceae).** A species with bipolar range, mostly distributed in arctic regions of the Northern Hemisphere extending southward to mountainous regions of cool temperate latitudes and after extensive disjunction reappearing in the polar zone of the Southern Hemisphere. It typically grows in large late snowbeds and on the shores of glacier-fed brooks. The general distribution of *Sanionia georgico-uncinata* includes Greenland, North America (Northwest Territories, Yukon, Alaska, Montana), northern Eurasia, and Antarctic (Hedenäs 2000; Ignatov et al. 2006; Ochyra et al. 2008). In North America, populations are mostly confined to the arctic and northern portions of the Rocky Mountains, becoming rare southward. The species is known in Montana only from two collections made by J. M. Holzinger in 1898 on Sperry Glacier (S, NY), in the northwestern part of the state (Hedenäs, pers. comm.).

During the summer expedition of 2008 (and later in 2009), the first author collected *Sanionia georgico-uncinata* from several populations in the Beartooth Plateau. These occurrences are a southeastward range extension of over 500 km from the nearest known populations in Montana. Almost simultaneously, in September of 2008, the species was collected in Colorado, growing in melt-water brooklets at Summit Lake on Mt. Evans (*L. Hedenäs* reg. no *B141515*, S; Hedenäs, pers. comm.). The Colorado discovery extended the range of the species 650 km further southeastward. Thus, this location is over 1150 kilometers southeast of those of previously reported specimens in

Montana and represents a significant extension of the known range of this moss in North America. All newly documented stations are confined strictly to upper subalpine and alpine elevations (2950–3260 m in Wyoming, 3900 m in Colorado), further documenting a highly disjunct arctic-alpine distribution.

Sanionia georgico-uncinata is separated from the other North American *Sanionia* species by the following key characters: its reduced and irregularly perforate endostome, acute to rather suddenly acuminate inner perichaetial leaves with strongly denticulate or dentate upper margins, relatively shortly acuminate stem leaves with strongly denticulate margins and by the structure of the alar and supra-alar cells (Hedenäs 2000; Ochyra et al. 2008).

Identification of *Sanionia georgico-uncinata* is problematic without sporogones; unfortunately, plants with capsules are rare. Reported below are only fertile specimens with mature sporogones.

Collection Data. Wyoming, Park Co., SNF, Beartooth Plateau: alpine *Caltha leptosepala* + *Sedum* sp. + *Carex* spp. – Bryidae fen in small depression beside the head of National Forest Trail # 623, 100-150 m E of Beartooth Scenic Byway, on wet peaty soil, locally abundant, forms pure mats and assoc. with *Plagiomnium ellipticum, Polytrichum juniperinum, Sarmentypnum exannulatum, S. sarmentosum*, S+, T58N R104W S28, 44°58.770-775' N, 109°25.530-540' W, elev. ca. 10,700 ft (3260 m), 19 Aug 2008, *Kosovich-Anderson 3430* (COLO, MO, S); unnamed tributary of Frozen Lake, seepage slope, on soaked peaty soil and wet clay along streamlets, snow melt area, in pure mats and assoc.: *Polytrichastrum sexangulare*, *Polytrichum juniperinum*, and *Brachythecium brandegei* (the latter is a rare alpine species, endemic of Colorado and Wyoming (Kosovich-Anderson & Ignatov 2010)), S+, T58N R104-105W S31&36, 44°58.050-060' N, 109°28.870-890' W, elev. ca. 10,500 ft (3200 m), 14 Aug 2008, *Kosovich-Anderson 2626A*; head of an unnamed tributary to Littlerock Creek, 0.8 km E of Christmas Lake, a basin toe slope alpine fen "Littlerock Creek Fen", *Salix planifolia* – Bryidae hummocks, on wet peaty soil, in pure mats, S+, T58N R104W S34, 44°58.050-055' N, 109°24.840-850' W, elev. ca. 10,650 ft (3250 m), 21 Aug 2008, *Kosovich-Anderson 3558*; broad subalpine valley overlying Quaternary glacial deposits, approx. 1 mi E-SE of Sawtooth Lake, Sawtooth Palsa Fen with raised peat overlying permafrost, *Salix* sp. - *Sphagnum warnstorfii*, on wet peaty soil, S+, T57N R104W S29, 44°53.670-675' N, 109°27.540-550'W, elev. ca. 9680 ft (2950 m), 25 Aug 2009, *Kosovich-Anderson 5752.* *Wyoming's Sawtooth Palsa Fen is the only known occurrence of a palsa-type fen in the lower 48 states (Heidel et al. 2008).

***6. THUIDIUM RECOGNITUM* (Hedwig) Lindberg (Thuidiaceae).** Fig. 4. A species and genus new to Wyoming. *Thuidium recognitum* is a large and beautifully pinnately branched moss widely distributed in the circumboreal zone of Eurasia and North America, where it occurs in woodlands and wet meadows, on shady soil and humus, infrequently on rotting wood and rocks, on sheltered banks, often indicating rich habitats and usually confined to calcareous regions (Lawton 1971; Ignatov & Ignatova 2004; Frey et al. 2006). "*Thuidium* is common and species diverse in the eastern United States as well as in most of the Northern Hemisphere. Its absence from western North America is nearly complete except for an arc of distribution that extends from eastern North America into the high Arctic thence southward in the mountains of Alaska and British Columbia barely reaching Washington State." (Norris & Shevock 2004, p. 248–249). *T. recognitum* also is known from Oregon, Idaho, Montana, and South Dakota (Lawton 1971; Crum & Anderson 1981; Elliott 1993).

Thuidium recognitum is infrequent or even rare in Wyoming, where it occurs close to its distributional limit in this portion of its range. On the Beartooth Plateau, it was discovered in wet spruce forest, in sheltered lowland at montane lake, where it grows in pure "carpets" and mixed-

species mats. The community is generally characterized by high bryophyte diversity and abundance, creating for Wyoming an unusual picture of a northern boreal forest with bryophyte coverage up to 100%, dominated by typical luxuriant form of *Hylocomium splendens* combined with *Aulacomnium palustre*, *Climacium dendroides*, *Helodium blandowii*, *Rhizomnium* spp., *Thuidium recognitum*, *Marchantia alpestris*, and others.

Collection Data. Wyoming, Park Co., SNF, Beartooth Plateau: Lily Lake shore, wet spruce forest, *Picea* sp. – *Alnus incana* – *Linnaea borealis* + *Equisetum variegatum* - Bryidae, under recently fallen spruce, on wet litter and humus, locally abundant, T57N R107W S6, 44° 56.880-890' N, 109° 42.930-940' W, elev. ca. 7,700 ft (2350 m), 17 Aug 2008, *Kosovich-Anderson 3047* (COLO, MO).

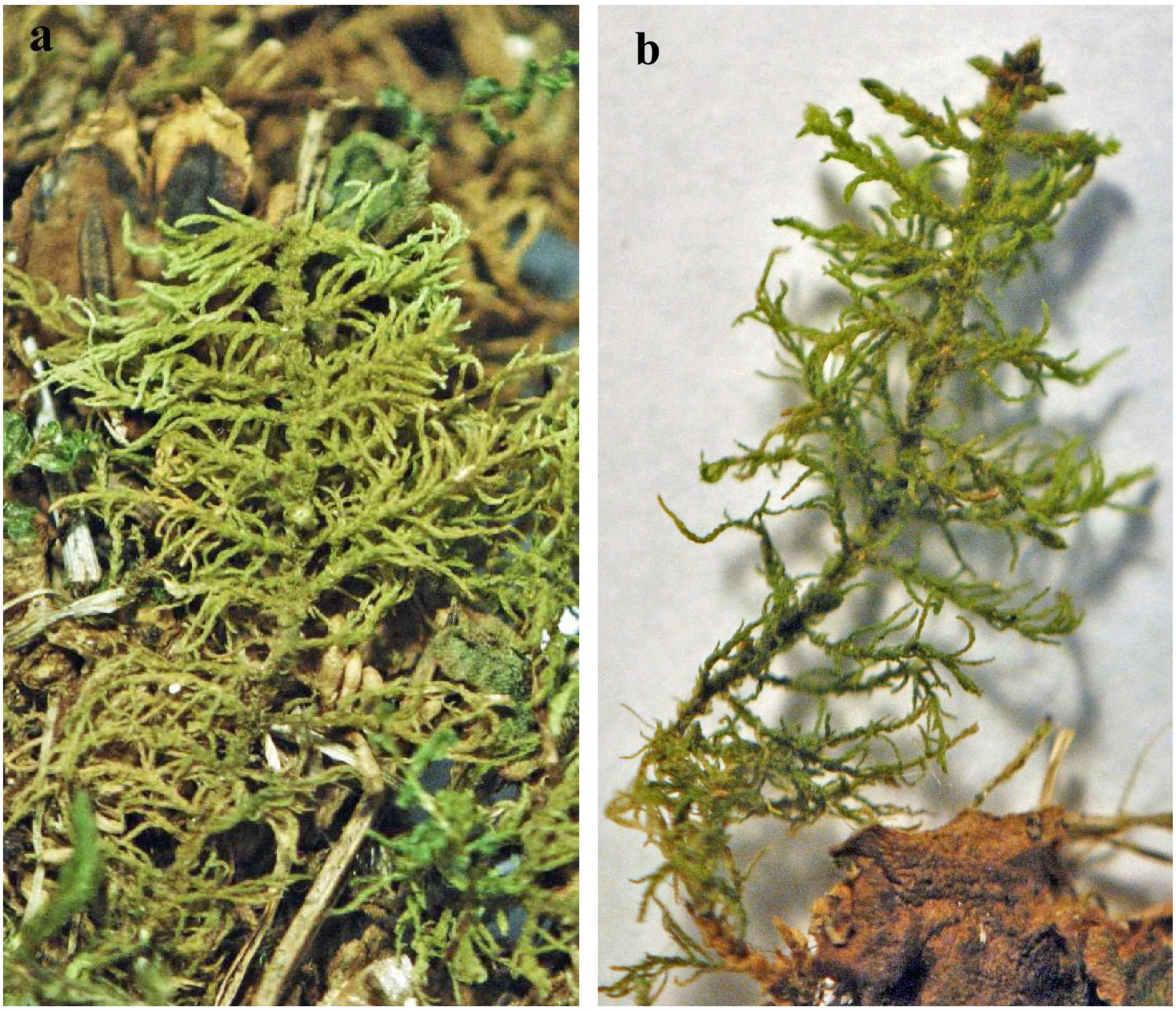

Figure 4. *Thuidium recognitum* from Wyoming's Beartooth Plateau: (a) plant in natural environment and (b) herbarium specimen. Photos by Y. Kosovich-Anderson.

The genus *Thuidium* Bruch & Schimper is new to Wyoming. The most striking distinction separating *Thuidium* from closely related *Abietinella* Müller Halle is its branching pattern –– the shoots of *Thuidium* are twice/several times pinnately branched vs. 1-pinnately branched in *Abietinella* (the generic name "*Thuidium*" alludes to branched habit of *Thuja*). Also, *Thuidium* has 2–3-pinnate branching paraphyllia and leaf cells 1-papillose abaxially whereas *Abietinella* has paraphyllia simple

or not strongly branching and cells 1-papillose on both leaf surfaces; there also are distinctions in the structure and color of axillary hairs (Buck & Crum 2010).

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